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FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE
INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
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USDA Forest Service
Research Note INT-239

December 1977

FIFTH-YEAR SEED:SEEDLING RATIOS OF LODGEPOLE PINE
BY HABITAT TYPE AND SEEDBED PREPARATION TECHNIQUE

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ABSTRACT

After the first and fifth growing seasons (nine seedbed treatments in each of three habitat types), seed:seedling ratios of lodgepole pine were inversely related to moistness of the site. On Pinus contorta/Purshia tridentata (droughty) and Pseudotsuga menziesii/Calamagrostis rubescens (medium moist and high competition), acceptable seed:seedling ratios were not attained without thorough site preparation. Cultivating gave the lowest seed:seedling ratio on the Pico/Putr type (301 seed to establish one seedling), followed by spraying (512:1), furrowing, and trenching (both 550:1). On the Psme/Caru type, cultivating, spraying, brushblading, and scalping all gave ratios less than 100:1. Burning was not desirable on this type, probably because it stimulated grass growth. On the cool and moist Abies lasiocarpa/Vaccinium scoparium type, ratios on all seedbeds might produce acceptable stocking levels (assumed to be 3,000 trees per hectare (1,200 per acre) at age 5) depending on available seed. On this latter type, lack of site preparation may be a useful tool in controlling overstocking.

Survival in the fifth year (as a percentage of seedlings alive in the first year) varied from 0 to 33 percent on Pico/Putr, 2 to 60 percent on Psme/Caru, and 53 to 143 percent (net ingress of seedlings) on Abia/Vasc habitat types.

KEYWORDS: lodgepole pine, regeneration, seed:seedling ratios, seedbed preparation

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To evaluate the probability of successful natural regeneration on a particular site, a manager must estimate (1) available seed and (2) seed:seedling ratios after stocking levels have become reasonably stable (seed:seedling ratio indicates the number of seed required to establish one seedling). The latter will vary depending on a number of environmental and management factors, among them habitat type and the type of slash disposal-seedbed preparation technique that the manager chooses.

This note reports fifth-year seed:seedling ratios of lodgepole pine on nine seedbed treatments in each of three habitat types in southwest Montana and southeast Idaho. First-year results were reported by Lotan (1964) and will also be summarized herein.

METHODS

Experimental Design and Study Areas

Nine seedbed treatments were replicated three times in a randomized block design on each of three physiographic areas (table 1).

Table 1.--Location and characteristics of experimental areas

Area and National Forest	Soil	Habitat type (Pfister and others 1977)	Slope	Elevation
			Percent	m
West Yellowstone, Gallatin N.F.	Alluvial obsidian sands and gravel	<i>Pinus contorta</i> / <i>Purshia tridentata</i>	<5	2,030
Island Park, Targhee N.F.	Alluvial rhyolitic loam over cobble	<i>Pseudotsuga menziesii</i> / <i>Calamagrostis rubescens</i>	5 to 15	1,970
Moose Creek Plateau, Targhee N.F.	Gravelly clay loam developed from various volcanic rocks	<i>Abies lasiocarpa</i> / <i>vaccinium scoparium</i>	5 to 15	2,364

Treatments

Rectangular 8-m² plots (2 × 4 m)^{2/}, oriented with their long axes in a north-south direction, were treated during the summer of 1961 as follows:

1. Check. Natural undisturbed duff.
2. Burned. Areas where slash had been piled and burned.
3. Disked. Plots were disked in an east-west direction by a lightweight disk harrow.
4. Scalped. Area was stripped of all vegetation by using a shovel to simulate scalping by a dozer blade.

^{2/} 8 m² = 2 milacres; 1 m = 3.28 feet; 1 cm = 0.4 inch; 1 kg = 2.2 pounds;
kg/ha = 0.9 × lb/acre.

5. Scalped and cultivated. Area was stripped of all vegetation, and the soil was loosened to a depth of 15 cm by using a shovel.

6. Scalped, cultivated, and sprayed. Area was treated as in treatment 5 and in addition was sprayed with Dalapon grass killer (2,2-dichloropropionic acid) at a rate of 14 kg/ha.

7. Simulated brushblade scarification. Quadrat was partially scalped (about 90 percent of the area) of vegetation, and small trenches (about 40 cm apart and 2 to 7 cm deep) were dug with a mattock in an east-west direction.

8. Furrowed. Trenches 7 to 10 cm deep were dug in an east-west direction, leaving a sharp, perpendicular edge to the south to provide maximum shade to seedlings in the trench.

9. V-shape trenched. Trenches 7 to 10 cm deep were dug in an east-west direction, leaving a 45-degree angle to both the north and south to provide seedlings with minimal shade.

Seeding

The lodgepole pine seed used in this study were collected on the Targhee National Forest in 1958 at an elevation of 2,100 m. Seed were 55 percent viable (standard germination test after Endrin and anthraquinone treatment) and were treated with 17.5 percent anthraquinone and 2.5 percent Endrin (clean, untreated seed basis) to repel birds and rodents. The seed were broadcast sown in October 1961. They were not covered, as the intent was to simulate natural regeneration rather than direct seeding. A large amount of seed (2,200 viable seed per 4 m², equivalent to 2,200,000 seed per acre) was used to insure an adequate seedling catch and thereby permit statistical analysis of data from all treatments. Failure on adverse seedbeds would have hindered analysis of data. Plots were located at least 150 m from the nearest timber edge, well beyond the distance that seed are normally transported by wind. Therefore, we feel that input of seed from the adjacent timber was negligible. Nevertheless, the seed:seedling ratios calculated herein should be considered as minimum values.

Measurements

During the first growing season (1962), seedlings were counted weekly during the early part of the season and biweekly after both germination and mortality declined. See Lotan (1964) for complete data. Soil moisture (percent by weight) was determined at a depth of 15 cm six times during the first season. Survival following the fifth growing season was determined in October 1966 by the same procedure as in 1962.

RESULTS AND DISCUSSION

Highest fifth-year seed:seedling ratios were on the *Pinus contorta*/*Purshia tridentata* (Pico/Putr) habitat type, followed by *Pseudotsuga menziesii*/*Calamagrostis rubescens* (Psme/Caru), and *Abies lasiocarpa*/*Vaccinium scoparium* (Abla/Vasc) (table 2). Assuming that soil moistures measured in 1962 were indicative of general site differences in water availability (which they probably were), seed:seedling ratios were inversely related to the moistness of the habitat (an observation which is not too surprising) (fig. 1).

Site preparation techniques that produced the best survival were those that increased available soil moisture and decreased competition. The treatment with no site preparation (check plots) had very high seed:seedling ratios in both the Pico/Putr and Psme/Caru types. Based on 1 year's soil moisture measurements, the former is very

Table 2.--Seed:seedling ratios at the end of the first and fifth growing seasons, by seedbed treatment and habitat type (* No surviving seedlings)

Seedbed treatment	Habitat type								
	<i>Pinus contorta/ Purshia tridentata</i>			<i>Abies lasiocarpa/ Vaccinium scoparium</i>			<i>Pseudotsuga menziesii/ Calamagrostis rubescens</i>		
	GROWING SEASON			GROWING SEASON			GROWING SEASON		
	First	Fifth	% Surv. Years 1-5	First	Fifth	% Surv. Years 1-5	First	Fifth	% Surv. Years 1-5
Check	367:1	*∞	0	733:1	512:1	143	132:1	7,333:1	2
Burned	150:1	733:1	20	550:1	468:1	118	440:1	7,333:1	6
Disked	267:1	∞	0	49:1	81:1	60	81:1	265:1	31
Scalped	195:1	957:1	20	147:1	154:1	95	29:1	85:1	34
Trenched	33:1	550:1	6	22:1	49:1	45	28:1	512:1	5
Brushblade	112:1	1,692:1	7	28:1	54:1	52	22:1	63:1	35
Sprayed	129:1	512:1	25	42:1	63:1	67	32:1	53:1	60
Furrowed	46:1	550:1	8	19:1	31:1	61	27:1	147:1	18
Cultivated	101:1	301:1	34	21:1	33:1	64	30:1	56:1	54

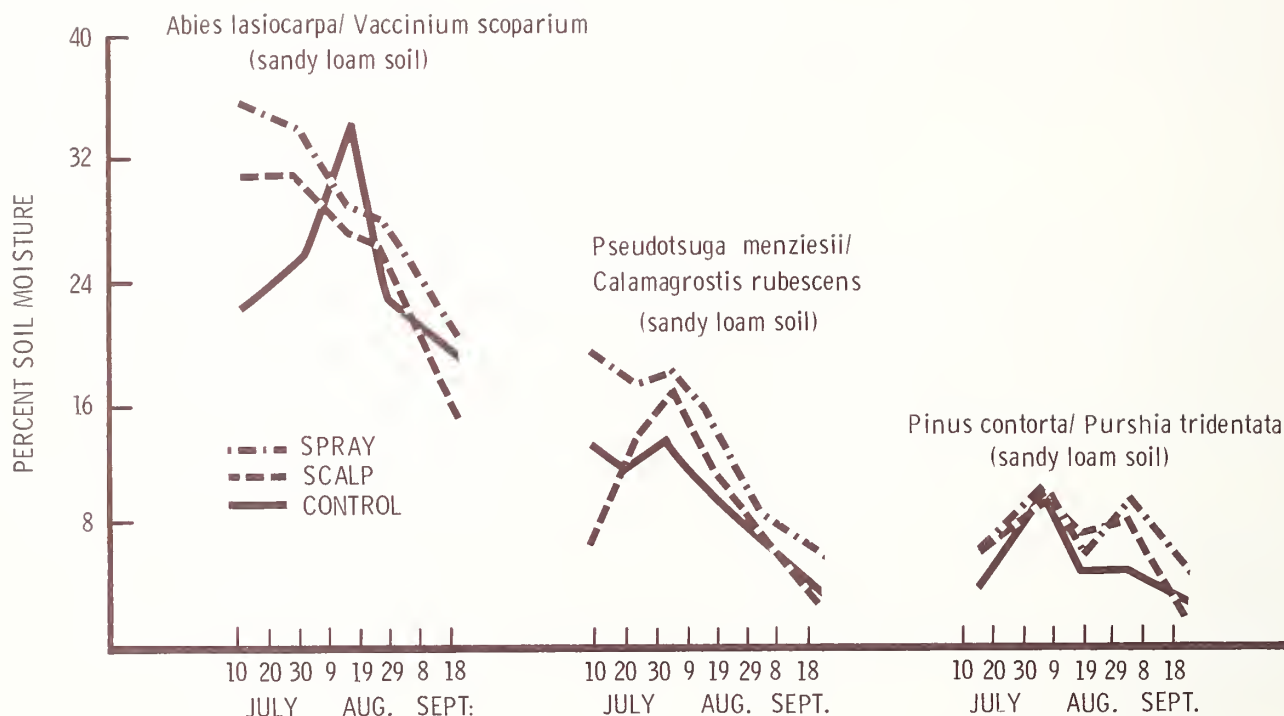


Figure 1.--Percent soil moisture at 15 cm depth for representative seedbed treatments on three habitat types, 1962.

droughty (fig. 1), and the latter, though relatively moist, is likely to have severe competition on unprepared seedbeds. On the most favorable site (Abla/Vasc), seed: seedling ratios on unprepared seedbeds were high, but still low enough to provide an acceptable stand of seedlings if available viable seed run as high as 2,500,000/ha (1,000,000/acre). This latter figure is not unreasonable in lodgepole pine stands where a majority of trees bear serotinous cones. See Lotan and Jensen (1970) for methods of computing available seed. Where overstocking has been a problem in lodgepole pine, little or no site preparation may be a useful control technique.

With the exception of the Abla/Vasc type, seed:seedling ratios after the fifth season are very much higher than after the first. Our data do not allow a determination of the point at which mortality stabilizes. However, managers should be extremely cautious about projecting ultimate stand stocking levels from survival data taken during the first few years of seedling establishment. (The decrease in seed:seedling ratio from the first to the fifth growing season on check plots and burned plots in the Abla/Vasc type is likely due to seedlings that emerged after the first-year measurements.) As a rough guide, the percentage survival figures given in table 2 may be used to estimate future stocking levels from first-year seedling counts.

Three thousand trees per hectare (1,200 per acre) at 5 years of age is a desirable stocking goal (Cole, D. M., personal oral communication). This is approximately three times greater than the optimum number of well-spaced trees, but is necessary to achieve uniform stocking. (With the site uniformly covered, thinning can be used to optimize spacing.) Seed required to produce this stocking level is given in table 3.

Table 3.--Viable seed required to produce 3,000 trees per ha (1,200 per acre) at 5 years of age (*No surviving seedlings)

	Habitat Type		
	<i>Pinus contorta/</i> <i>Purshia tridentata</i>	<i>Abies lasiocarpa/</i> <i>Vaccinium scoparium</i>	<i>Pseudotsuga menziesii/</i> <i>Calamagrostis rubescens</i>
----- Seed/ha (acre) -----			
Check	*∞	1,537,000 (615,000)	22,000,000 (8,800,000)
Burn	2,200,000 (880,000)	1,400,000 (560,000)	22,000,000 (8,800,000)
Disked	∞	238,000 (95,000)	800,000 (320,000)
Scalped	2,375,000 (1,150,000)	462,000 (185,000)	250,000 (100,000)
Trenched	1,650,000 (660,000)	150,000 (60,000)	1,537,000 (615,000)
Brushblade	5,000,000 (2,000,000)	162,000 (65,000)	188,000 (75,000)
Sprayed	1,537,000 (615,000)	188,000 (75,000)	162,000 (65,000)
Furrowed	1,650,000 (660,000)	88,000 (35,000)	438,000 (175,000)
ivated	900,000 (360,000)	100,000 (40,000)	162,000 (65,000)

These data were derived in a restricted geographic locale. In the absence of better information, they can be used to approximate what might be expected on similar habitat types elsewhere. However, the following limitations should be kept in mind:

1. The seed that we used were treated to discourage predation by rodents. Our data (unpublished) suggest that 30 to 50 percent of a seed crop may be eaten before the seed germinate. If the seed treatment was effective, seed loss will have been greatly reduced in our study, and seed:seedling ratios under natural conditions would be about twice as high as those given here. On the other hand, if the treatment wasn't effective (which it may not have been), the large amount of seed applied on a relatively small area may have resulted in greater than normal consumption by rodents. This would put our ratios higher than those occurring under natural conditions.

2. The burned plots were located where slash had been piled and burned. This generally results in severe soil alteration (Vogl and Ryder 1969) and cannot be related to lower intensity fires that occur when slash is broadcast burned.

3. Seed:seedling ratios may vary a great deal with short-term climatic changes. Our data represent a single 5-year period and reflect the weather during that 5-year period and no other. July rains during the first growing season were heavier than average, which undoubtedly reduced seedling mortality. In the second year, July rainfall was less than average. "Average" weather is rarely, if ever, experienced in nature. Variability is the normal pattern, and this variability may significantly alter seedling survival.

4. Although ease of regeneration increased with greater moisture in this study, the same trend cannot be extrapolated to all habitat types. Mesic (warm and moist) types, such as the grand fir series, which are characterized by high levels of competition, will likely be difficult to regenerate without thorough site preparation.

Remember our seed:seedling ratios are rough estimates. Because of the limitations stated above (especially 1 and 3) plus the many subtleties of a natural environment that cannot be duplicated in a controlled study, managers should not totally accept these (and all) general guidelines and should conduct regular on-the-ground surveys to check the accuracy of predictions.

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FEB 14 1973

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